



AMS-02-TOF

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Preparato da: <i>Prepared by:</i>	Nome & Funzione <i>Name & Function</i>	Firma <i>Signature</i>	Data <i>Date</i>
Approvato da: <i>Approved by:</i>	G. Laurenti F. Palmonari		
Applicazione autorizzata da: <i>Application authorized by:</i>	G. Laurenti		
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AMS-02-TOF

UPPER TOF THERMAL TEST PROCEDURE

N° Doc: AMS-TOF-PRO-002
Doc N°:
Ediz.: 1 Data: 28/05/2007
Issue:
Pagina 2 di 41
Page

REGISTRAZIONE DELLE MODIFICA / CHANGE RECORD

EDIZIONE / ISSUE	DATA DATE	AUTORIZZAZIONE CHANGE AUTHORITY	OGGETTO DELLA MODIFICA E SEZIONI AFFETTE REASON FOR CHANGE AND AFFECTED SECTIONS
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PAGINA PAGE	EDIZIONE ISSUE	PAGINA PAGE	EDIZIONE ISSUE	PAGINA PAGE	EDIZIONE ISSUE	PAGINA PAGE	EDIZIONE ISSUE	PAGINA PAGE	EDIZIONE ISSUE
1 - 41	1								

 AMS-02-TOF <small>UPPER TOF THERMAL TEST PROCEDURE</small>	N° Doc: Doc N°: Ediz.: Issue: Pagina Page	AMS-TOF-PRO-002 1 Data: 28/05/2007 4 di of 41
--	--	---

TABLE OF CONTENT

1. SCOPE	6
2. DOCUMENTS.....	7
2.1 APPLICABLE DOCUMENTS	7
2.2 REFERENCE DOCUMENTS.....	7
2.3 ACRONYMS.....	8
3. PARTICIPANTS REQUIRED.....	9
3.1 GENERAL	9
3.2 RESPONSIBILITY	9
3.3 NON CONFORMANCE AND FAILURES.....	9
3.5 CALIBRATION REQUIREMENTS	9
4. TEST ARTICLE	10
5. TEST CONFIGURATION	10
5.1 INTERFACES.....	11
5.2 THERMAL SENSORS.....	14
5.2.1 FLIGHT SENSORS AND TRP LOCATION	15
5.2.2 EXTERNAL TEST SENSORS LOCATION.....	17
5.2.3 TEMPERATURE CONTROL POINTS	22
5.3 FUNCTIONAL TESTS.....	22
6. INSTRUMENTATION AND TEST EQUIPMENT.....	22
7. TEST CONDITION	24
7.1 MEASUREMENTS ACCURACY.....	24
8. TEST PROFILE	25
9. TEST SUCCESS CRITERIA	26
10. TEST PROCEDURE VARIATION SHEET	26
11. TEST DATA SHEETS.....	28
11.1 DATA SHEETS FILLING UP	28
12. ANNEX A: FUNCTIONAL TEST (FOR INFN USE ONLY)	38
13. ANNEX B: PMT +COPPER SHIELD TV-TEST	40
14. ANNEX C: TEMPERATURE LEVEL DEFINITION	41

 AMS-02-TOF <small>UPPER TOF THERMAL TEST PROCEDURE</small>	N° Doc: Doc N°: AMS-TOF-PRO-002 Ediz.: 1 Data: 28/05/2007 Issue: Pagina Page 5 di 41
--	--

LIST OF TABLES

Table 6-1 Temperature sensors location	17
Table 7-1 INSTRUMENT LIST	23
Table 9-1 Temperatures for TOF.....	25

LIST OF FIGURES

Figure 6-1 UTOF Detector in TVT	10
Figure 6-2 Test configuration.....	11
Figure 6-3 Support structure.....	12
Figure 6-4 UTOF assembly, with the honeycomb panel (green)	12
Figure 6-5 Test Configuration	13
Figure 6-6 UTOF coordinate system	14
Figure 6-7 Box +X: Flight Sensors location	15
Figure 6-8 Box -X: Flight Sensors location	15
Figure 6-9 Box +Y: Flight Sensors location	16
Figure 6-10 Box -Y: Flight Sensors location	16
Figure 6-11 Thermal sensors location on lower honeycomb panel	18
Figure 6-12 Thermal sensors location on carbon fiber top panel	19
Figure 6-13 Thermal sensors location on upper lateral box +Y and +X	19
Figure 6-14 Thermal sensors location on upper lateral box -Y and -X	20
Figure 6-15 Thermal sensors location on lower lateral boxes +Y and +X	20
Figure 6-16 Thermal sensors location on lower lateral boxes -Y and -X	20
Figure 6-17 Thermal sensors location on ring support structure	21
Figure 6-18 TV Chamber minimal thermal sensors layout	21
Figure 6-19 CP location on the lateral boxes (+/-Y).....	22
Figure 6-20 CP location on the lateral boxes (+/-X).....	22
Figure 9-1 Thermal Vacuum Cycling (for the temperature level see Table 8-1).....	25
Figure 13-1 TV Chamber Flange Cabling.....	38
Figure 13-2 Functional Test Setup	39

 AMS-02-TOF <small>UPPER TOF THERMAL TEST PROCEDURE</small>	N° Doc: Doc N°: Ediz.: Issue: Pagina Page	AMS-TOF-PRO-002 1 Data: 28/05/2007 6 di of 41
--	--	---

1. SCOPE

This document describes the procedure applicable to the Thermal Vacuum Cycling (TVC) of the Upper Time of Flight detector (UTOF) equipment, which is part of Alpha Magnetic Spectrometer (AMS02) flight unit, to be performed during the acceptance campaign.

The main objectives of the test environment are provided to the payload developer (INFN) to:

- demonstrate the ability of equipment to operate when exposed to extreme operational temperatures after being exposed to extreme non-operational in vacuum environment.
- test the workmanship

In order to get these target the test consists of:

- Four cycles in vacuum chamber.

Before, during and after the test, the functional performance of the test item shall be checked in order to reveal potential functional degradation or malfunction.

The test results shall be collected in a dedicated Test Report.

 AMS-02-TOF <small>UPPER TOF THERMAL TEST PROCEDURE</small>	N° Doc: Doc N°: Ediz.: Issue: Pagina Page	AMS-TOF-PRO-002 1 Data: 28/05/2007 7 di 41
--	--	---

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD#	Doc Number	Issue	Date	Rev	Title
AD 1	AMS02-TN-004-CGS	3	19/05/2004		Preliminary thermal requirement for internal AMS02 interfaces

2.2 REFERENCE DOCUMENTS

RD#	Doc Number	Issue	Date	Rev	Title
RD 1	RICSYS-RP-CGS-008	1	30/09/2003		TOF Thermal control system design report
RD 2	ECSS-E10-03A		15/02/2002		Space engineering- Testing
RD 3	621-RICH 1913		5/4/2006		Fax from F. Palmonari to CGS: temperature levels, ANNEX C

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---	--	--	---

2.3 ACRONYMS

AD	Applicable Document
AMS	Alpha Magnetic Spectrometer
CGS	Carlo Gavazzi Space
CI	Configuration Item
CP	Control Point
DAQ	Data Acquisition
EGSE	Electronic Ground Segment Equipment
FM	Flight Model
FT	Functional Test
GMM	Geometrical Mathematical Model
MLI	Multi Layer Insulator
NA	Not Applicable
NCR	Non Conformance Report
P/N	Part Number.
PA	Product Assurance
PFM	Protoflight Qualification Model
PMT	Photo Multiplier T
PVS	Procedure Variation Sheet
QA	Quality Assurance
RD	Reference Document
RICH	Ring Image Cherenkov Counter
SFEC	Scintillator Front End Charge
S/N	Serial Number
TB	Thermal Balance Test
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TMM	Thermal Mathematical Model
UTOF	Upper Time of Flight
TRP	Temperature Reference Point
TV	Thermal Vacuum
TVC	Thermal Vacuum Cycling Test
USS	Unique Support Structure
UUT	Unit Under test

 AMS <small>Istituto Nazionale di Fisica Nucleare</small>	AMS-02-TOF <hr/> <small>UPPER TOF THERMAL TEST PROCEDURE</small>	N° Doc: Doc N°: Ediz.: Issue: Pagina Page	AMS-TOF-PRO-002 1 Data: 28/05/2007 9 di 41
--	--	--	---

3. PARTICIPANTS REQUIRED

3.1 GENERAL

All test will be performed under facility QA surveillance.

3.2 RESPONSIBILITY

The technical responsibility for testing and test results reporting is up to the **Mechanical Engineering Responsible of AMS Bologna**.

The test shall be run by skilled personnel under the surveillance of the Mechanical Engineering Responsible of AMS Bologna which will provide the test conductor.

Continuous witness of the test will be ensured by means of shifts: CGS Thermal Department will be providing a presence on call when running the step-by-step procedure described in the paragraph 12.

INFN-Bologna, being responsible of the design of the UTOF, will provide personnel to operate the UTOF detector (switching ON/OFF the instrument, verifying the performances, conduct the functional test).

Facility personnel, based on **Mechanical Engineering Responsible of AMS Bologna** input, shall operate the TV-Chamber in order to guarantee the test temperature level requirement are met.

3.3 NON CONFORMANCE AND FAILURES

Any malfunction/defect which occurs during the test will be processed with a Non Conformance Report.

3.4 CALIBRATION REQUIREMENTS

All instruments used for testing shall be calibrated.

Evidence of certification shall be provided by a label attached to the instruments itself, showing the calibration date, the expiring date and the signature of the operator.

All calibration certificates will be provided by the external facility upon request, in the facility test report.

4. TEST ARTICLE

The test article consists on the FM of the UPPER TOF (UTOF) Detector of AMS02.
 It shall be tested according to this procedure with the required procedure variation sheets.

The P/N of the test article(s) to be tested shall be recorded before starting the test on the step by step procedure sheets under "UNIT UNDER TEST" (UUT) table cell.

5. FACILITY

The selected test Facility is University of Perugia (Polo Scientifico Didattico di Terni - Laboratorio SERMS), in Terni – Italy.
 It is an external facility.

6. TEST CONFIGURATION

UTOF in flight configuration will be provided by INFN.

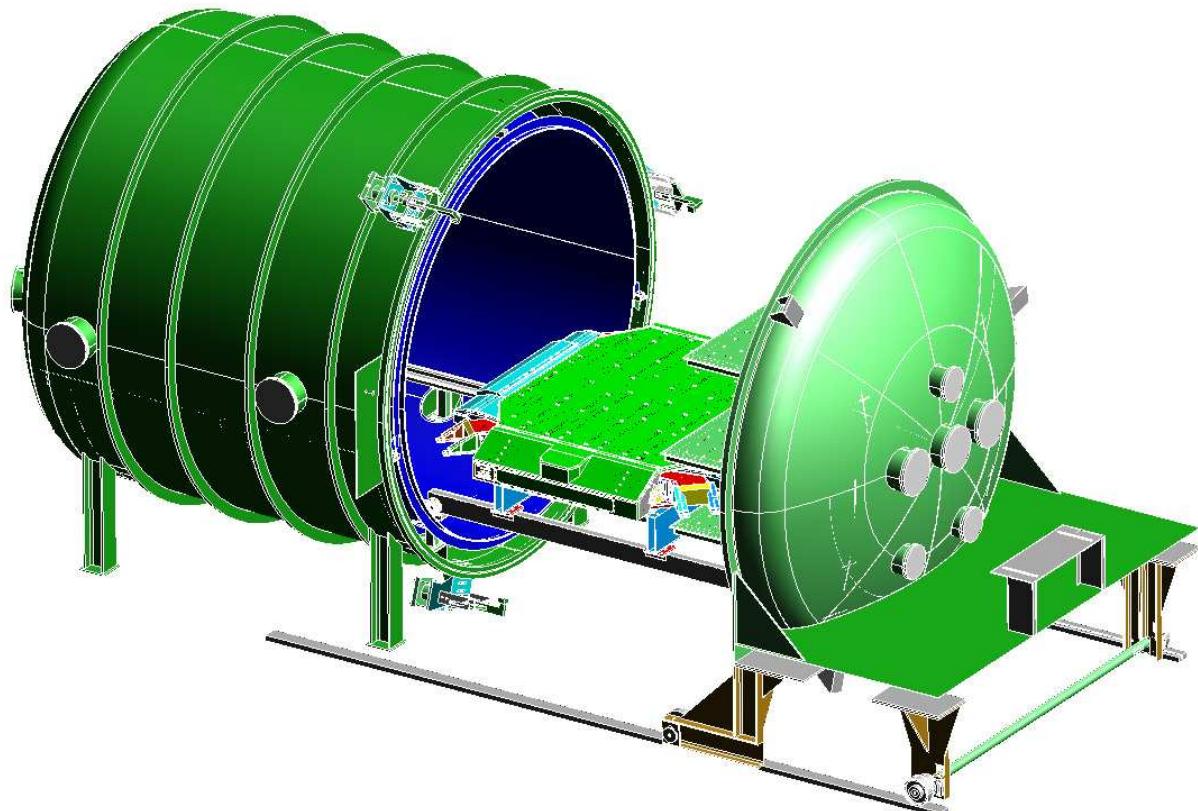


Figure 6-1 UTOF Detector in the thermal-vacuum chamber

UTOF will be moved into a Thermal Vacuum (TV) Chamber by the means of an appropriate crane and mounted on a dedicated support structure fixed to the chamber fixture.

In the next figure the test configuration is shown. In parenthesis the responsibility is indicated for each item to be provided for the test.

UTOF will not have the FM MLI -which is shared with other sub-detectors and cannot be physically installed on the standalone UTOF- and will be supported by 2 insulating feet, put on the facility rails.

The UTOF will be thermally coupled to the TV chamber shroud by radiation only, as this will be the typical heat transfer in flight conditions.

EGSE will be used to supply power to the UTOF and allow science data acquisition, by INFN.

The UTOF shall be connected to the relevant Electronic Ground Segment Equipment (EGSE) and supplied at the nominal operating voltage by INFN as well.

UTOF switch-on and switch-off and all the functional verifications are by INFN and under responsibility of INFN, both for what concern the execution and the results.

The Facility will provide:

- temperature sensors
- data acquisition and recording system.

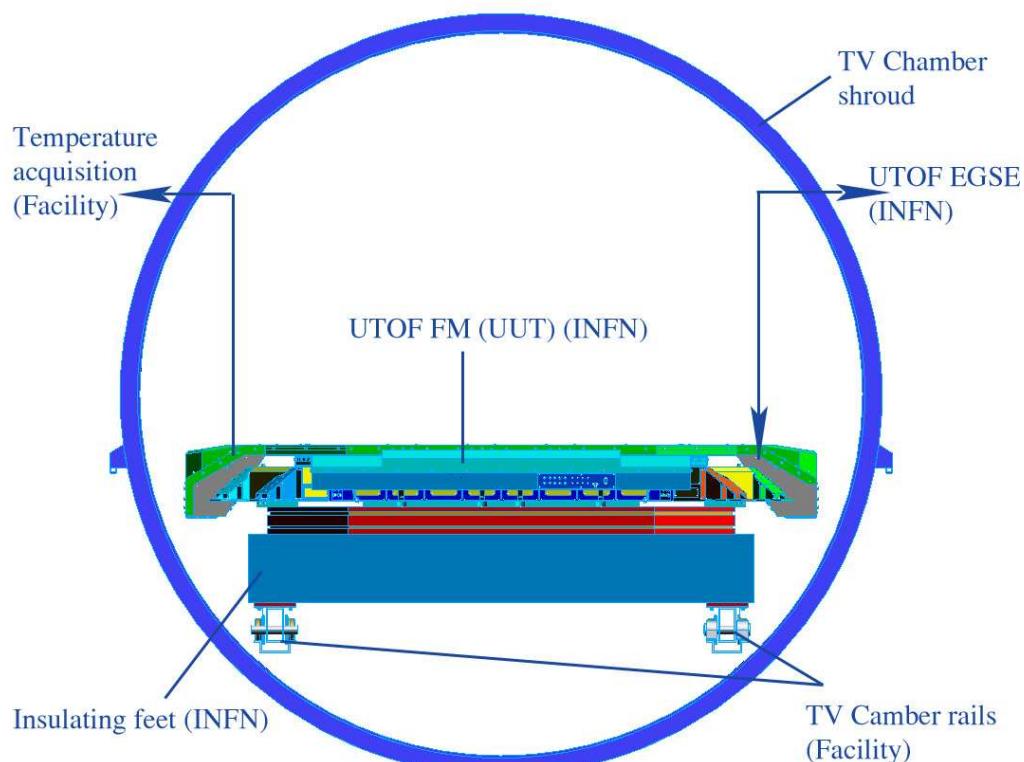


Figure 6-2 Test configuration

The TV Chamber used shall be capable to set the shroud temperature in a adequate range. The fixture temperature will change passively with the shroud one.

Test set up are described in the step-by-step procedure sheets provided in section 12.1 .

6.1 INTERFACES

The following figure shows the dedicated support structure made of an aluminium frame and Teflon insulating supports sized in order to minimize the conductive heat exchange between UUT and the TV Chamber rails

The following figures show the support structure.

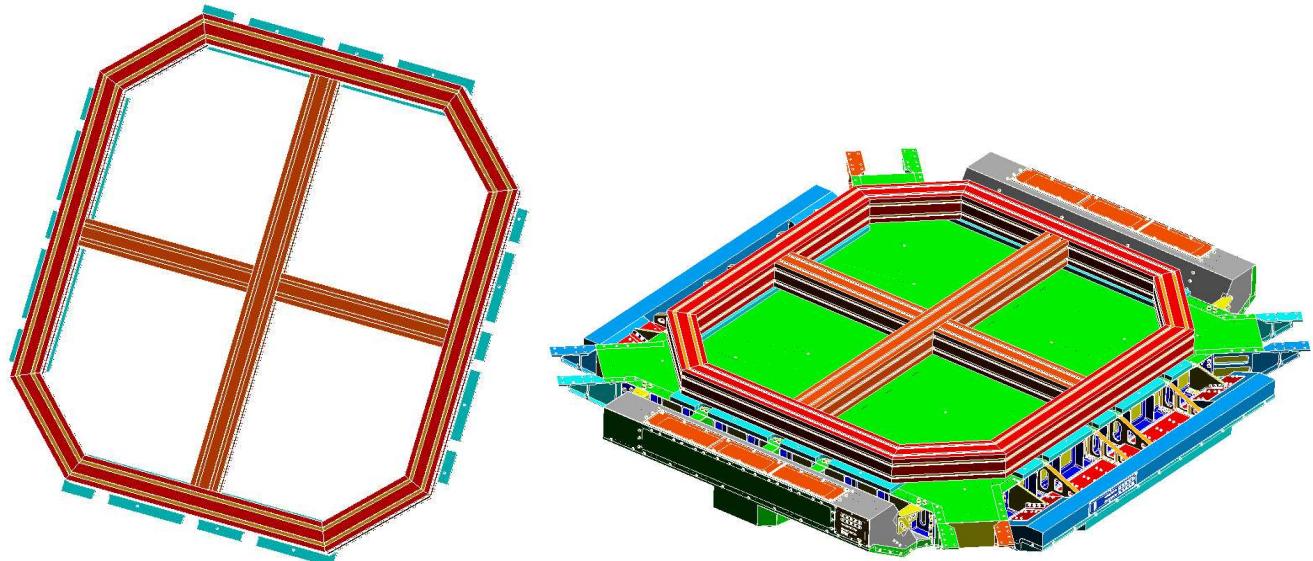


Figure 6-3 Support structure

Figure 6-5 shows the UUT as will be placed in the thermal-vacuum chamber. The heat exchange will be mainly via radiation. The FM model of UTOF alone will be let free to radiate toward the chamber shroud.

The chamber temperature will be set in order to impose the required temperature onto the TRP.

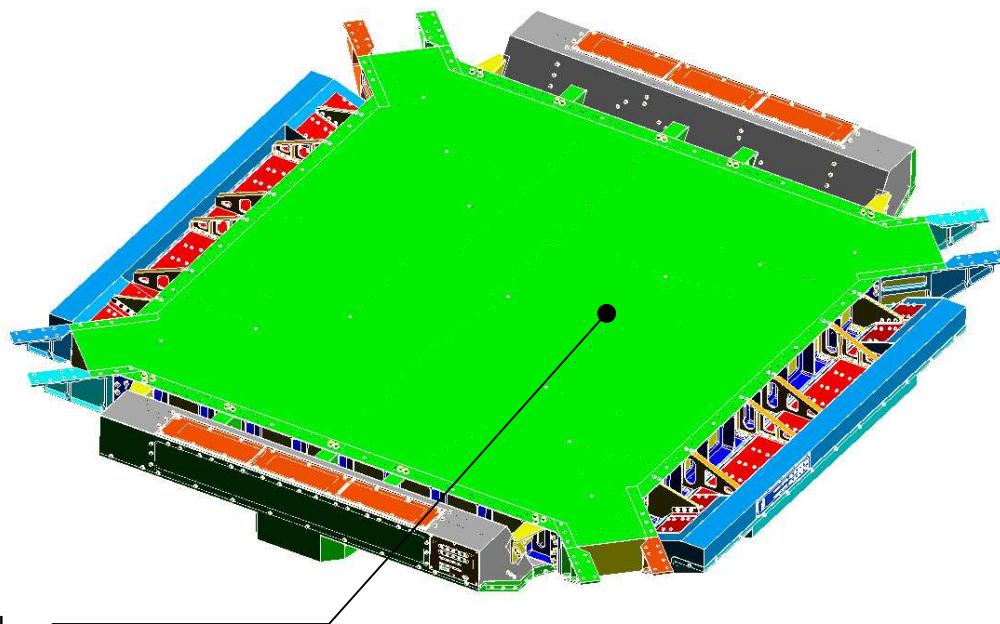


Figure 6-4 UTOF assembly, with the honeycomb panel (green)

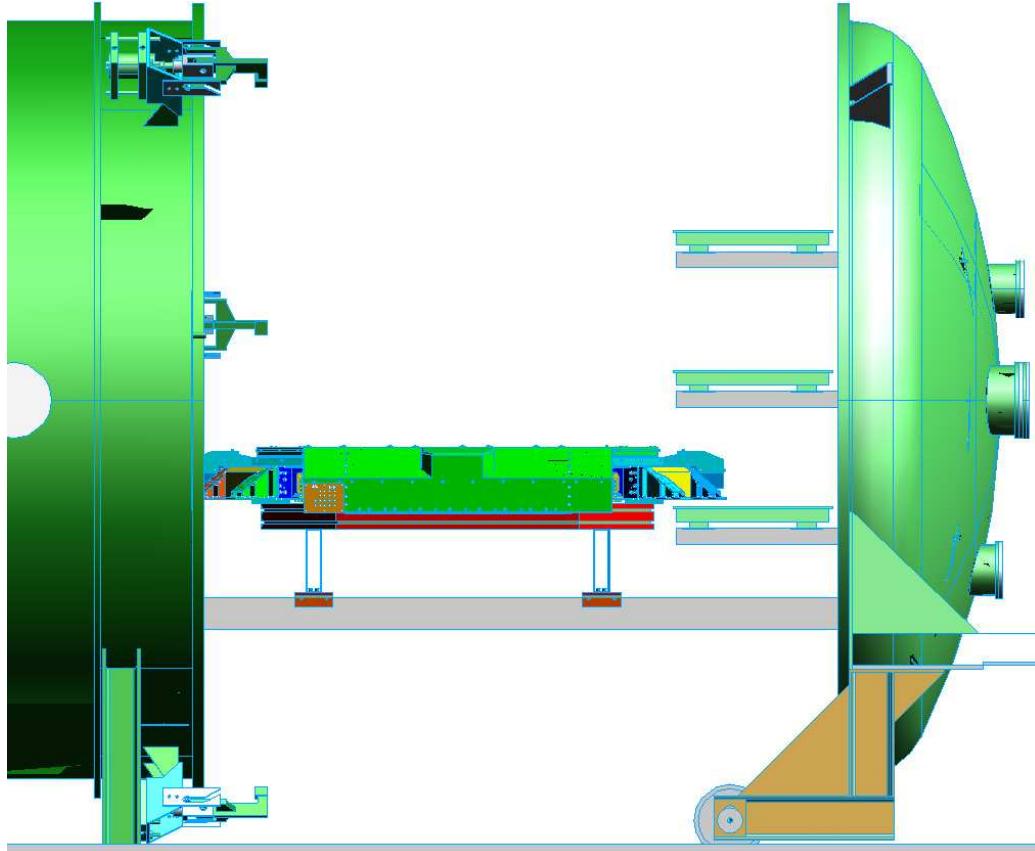
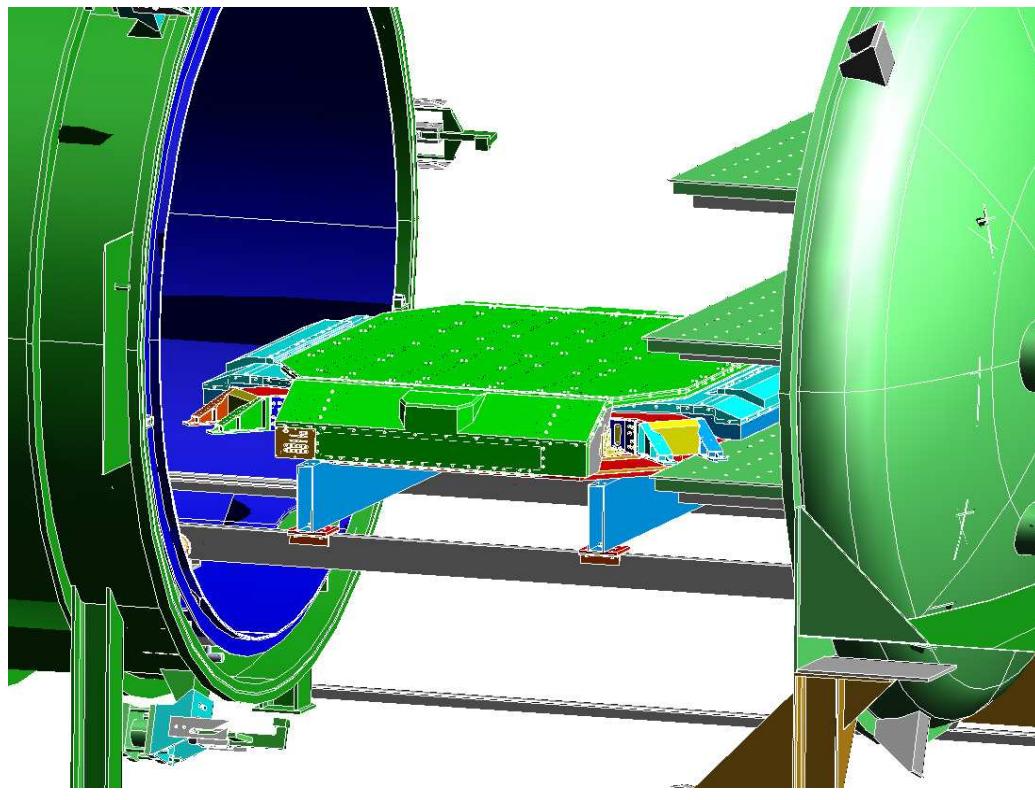


Figure 6-5 Test Configuration

6.2 THERMAL SENSORS

Three different kind of thermal sensors are foreseen during the test:

- 16 Flight Dallas Sensors; they are located internally on PMT Copper Shield and SFEC. These specific sensors have been mounted and are read-out under INFN responsibility.
- 14 Test Sensors (PT100) : located internally in the same position of the Flight Dallas sensors on SFEC and PMT Copper Shield. The sensor on the PMT Copper Shield represent also the TRP of the test.
- 44 Test Sensors (PT100): they are located externally

In the following paragraphs the different part of the TOF will be defined accordingly to this coordinate system:

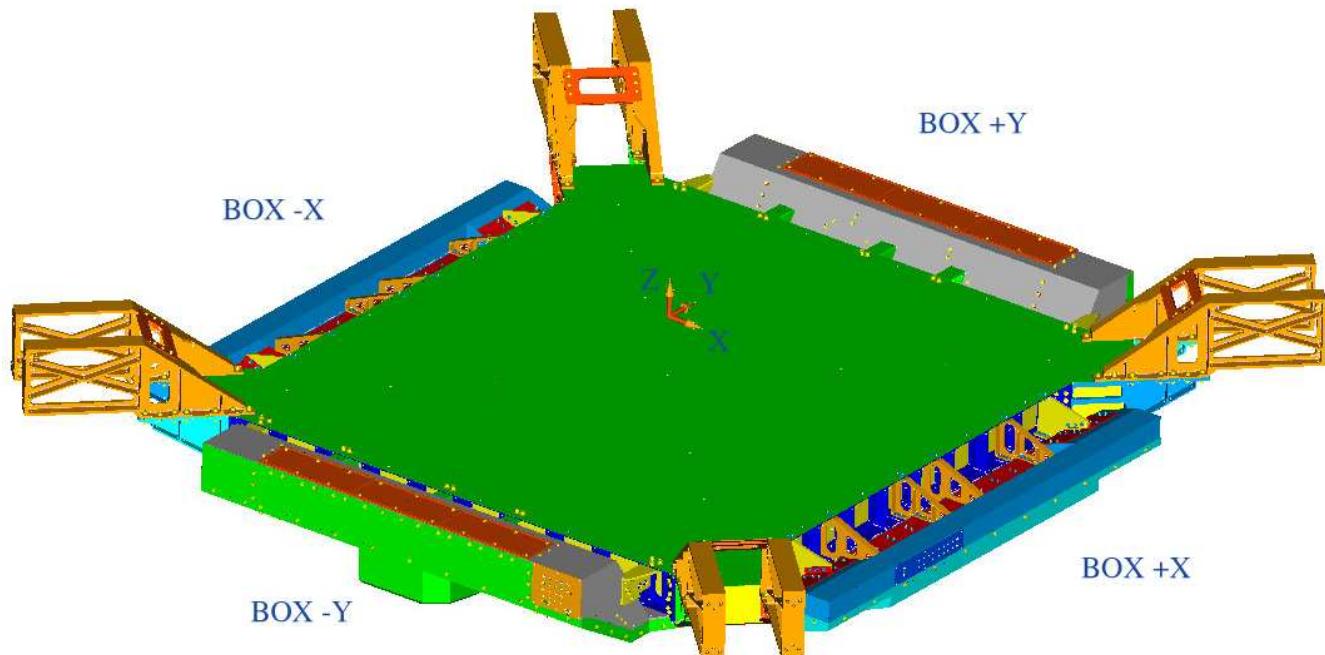


Figure 6-6 UTOF coordinate system

6.2.1 FLIGHT SENSORS AND TRP LOCATION

The PMTs are placed inside the UTOF, they have a Copper Shield where the flight temperature sensors (Dallas sensors) are located. In order to verify the correct calibration of the flight sensor, 14 test sensor (PT100) shall be placed in the same position of the Dallas sensor.

The Copper Shields are the TRP (Temperature Reference Points) of the test.

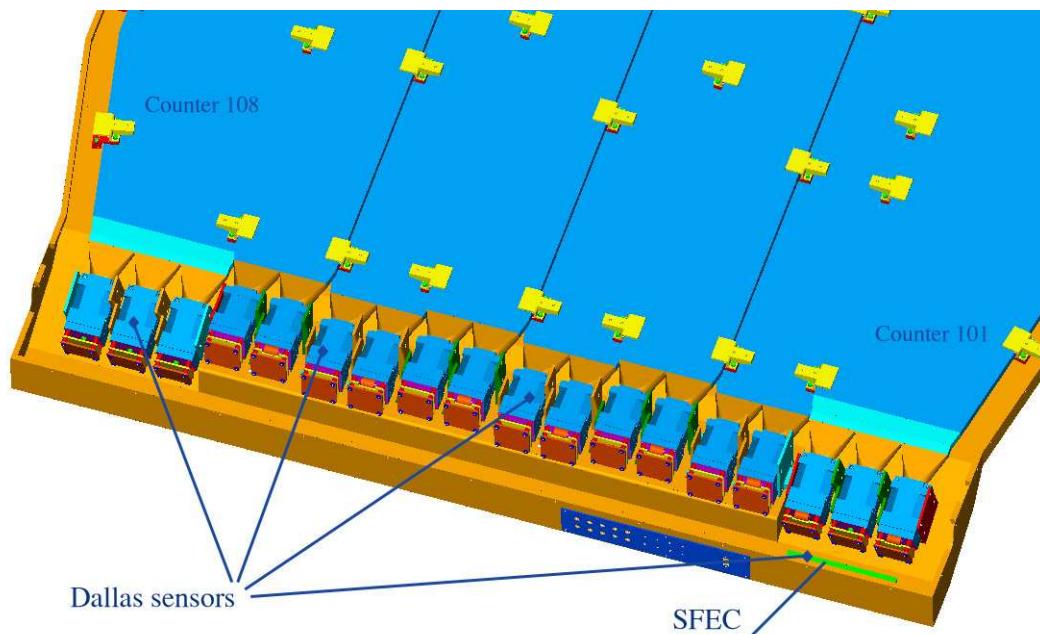


Figure 6-7 Box +X: Flight Sensors location

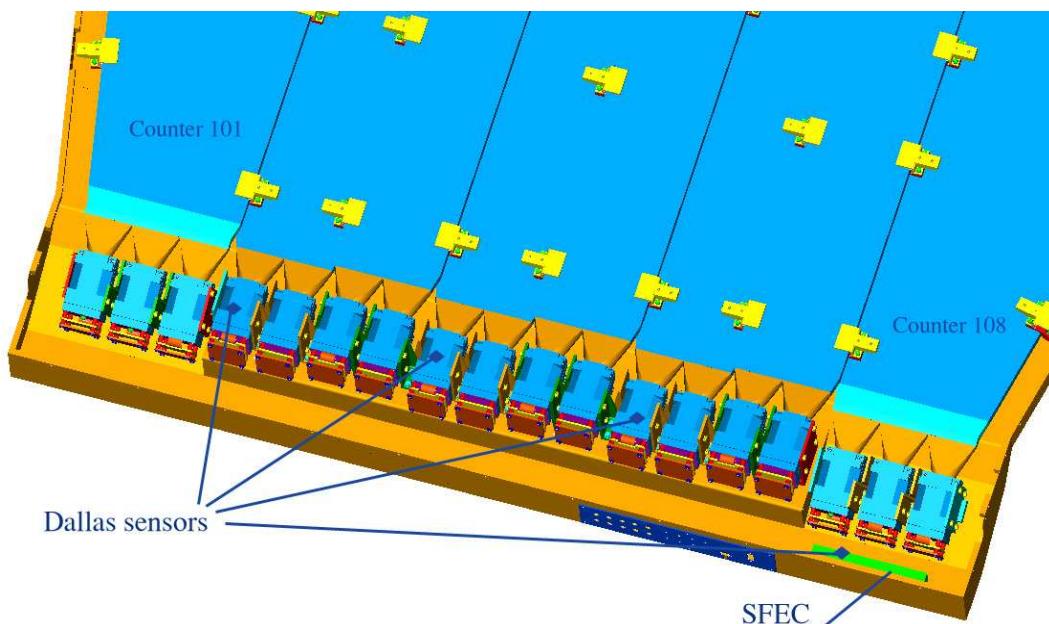


Figure 6-8 Box -X: Flight Sensors location

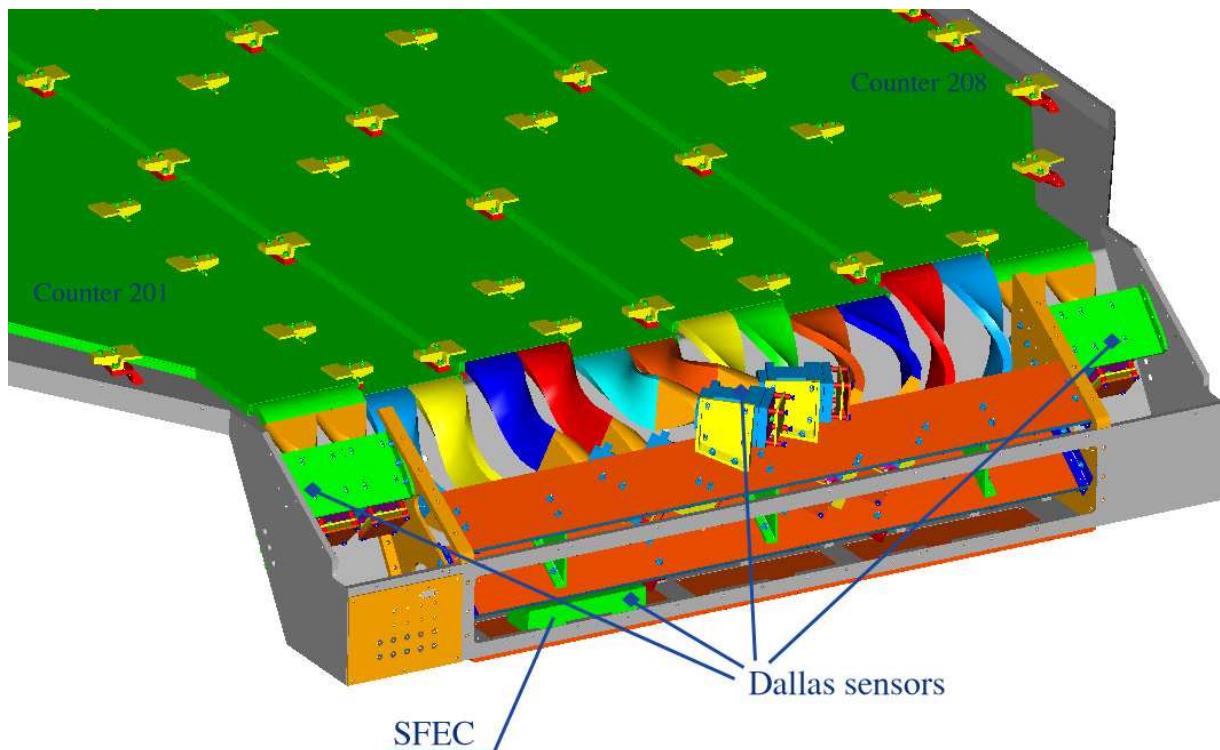


Figure 6-9 Box +Y: Flight Sensors location

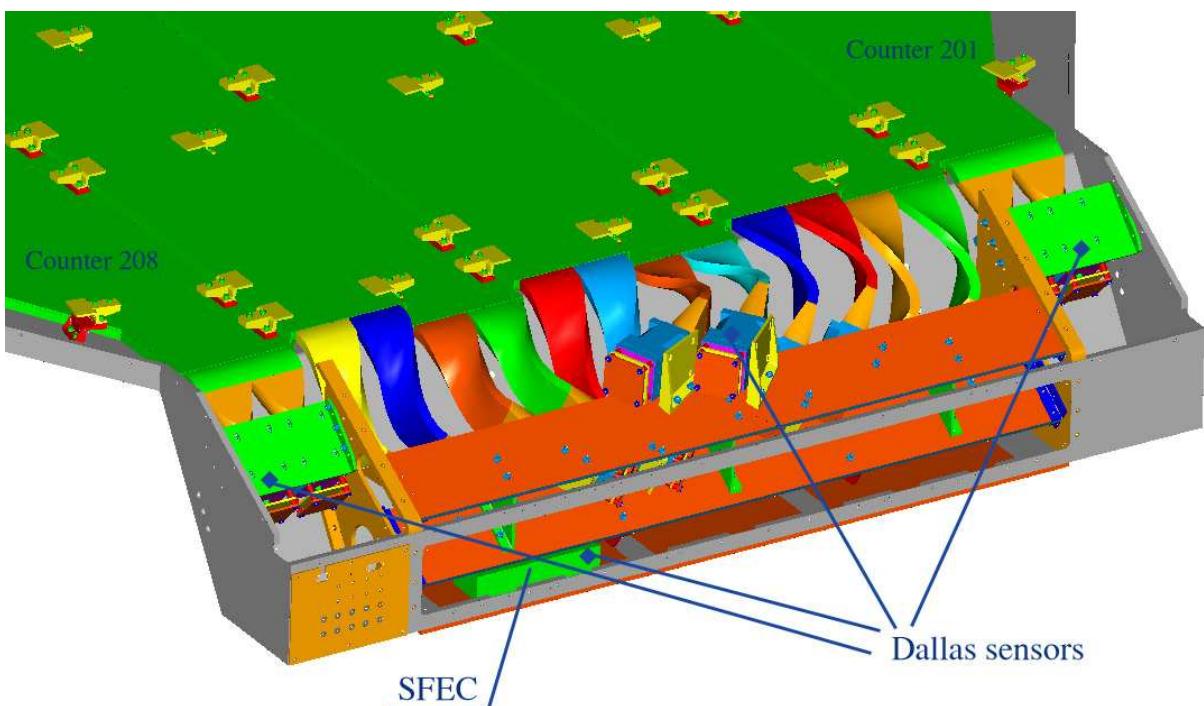


Figure 6-10 Box -Y: Flight Sensors location

6.2.2 EXTERNAL TEST SENSORS LOCATION

In addition to these flight sensors, at least 44 test sensors will be placed on the UTOF unit and their positions are described in Table 6-1 and can be seen from Figure 6-11 to Figure 6-17.

At least the following sensors shall be used:

Sensor	Position
1.	Lower honey comb panel center
2.	Lower honey comb panel center (red.)
3.	Lower honey comb panel first corner
4.	Lower honey comb panel first corner (red.)
5.	Lower honey comb panel second corner
6.	Lower honey comb panel second corner (red.)
7.	Carbon fiber top panel center
8.	Carbon fiber top panel center (red.)
9.	Carbon fiber top panel first corner
10.	Carbon fiber top panel first corner (red.)
11.	Carbon fiber top panel second corner
12.	Carbon fiber top panel second corner (red.)
13.	Carbon fiber lower/left side lateral box +Y (CP)
14.	Carbon fiber lower/ right side lateral box +Y (CP red.)
15.	Carbon fiber lateral/ left side lateral box +Y
16.	Carbon fiber lateral/ right side lateral box +Y
17.	Carbon fiber upper/ left side lateral box +X (CP)
18.	Carbon fiber upper/ right side lateral box +X (CP red.)
19.	Carbon fiber lateral/ left side lateral box +X
20.	Carbon fiber lateral/ right side lateral box +X
21.	Carbon fiber lower/ left side lateral box -Y (CP red.)
22.	Carbon fiber lower/ right side lateral box -Y (CP red.)
23.	Carbon fiber lateral/ left side lateral box -Y
24.	Carbon fiber lateral/ right side lateral box -Y
25.	Carbon fiber lower/ left side lateral box -X (CP)
26.	Carbon fiber lower/ right side lateral box -X (CP red.)
27.	Carbon fiber lateral/ left side lateral box -X
28.	Carbon fiber lateral/right side lateral box -X
29.	Upper/ left side lateral box +X
30.	Upper/center side lateral box +X
31.	Upper/ right side lateral box +X
32.	Upper/ left ordinate lateral box +Y
33.	Upper/ right ordinate lateral box +Y
34.	Upper/center lateral box +Y
35.	Upper/ left side lateral box -X

36.	Upper/center side lateral box -X
37.	Upper/ right side lateral box -X
38.	Upper/ left ordinate lateral box -Y
39.	Upper/ right ordinate lateral box -Y
40.	Upper/center lateral box -Y
41.	Support structure side +X
42.	Support structure side +Y
43.	Support structure side -X
44.	Support structure side -Y
A	TV Chamber bottom wall
B	TV Chamber left wall
C	TV Chamber top wall
D	TV Chamber right wall
E	TV Chamber rear wall
F	TV Chamber front wall

Table 6-1 Temperature sensors location

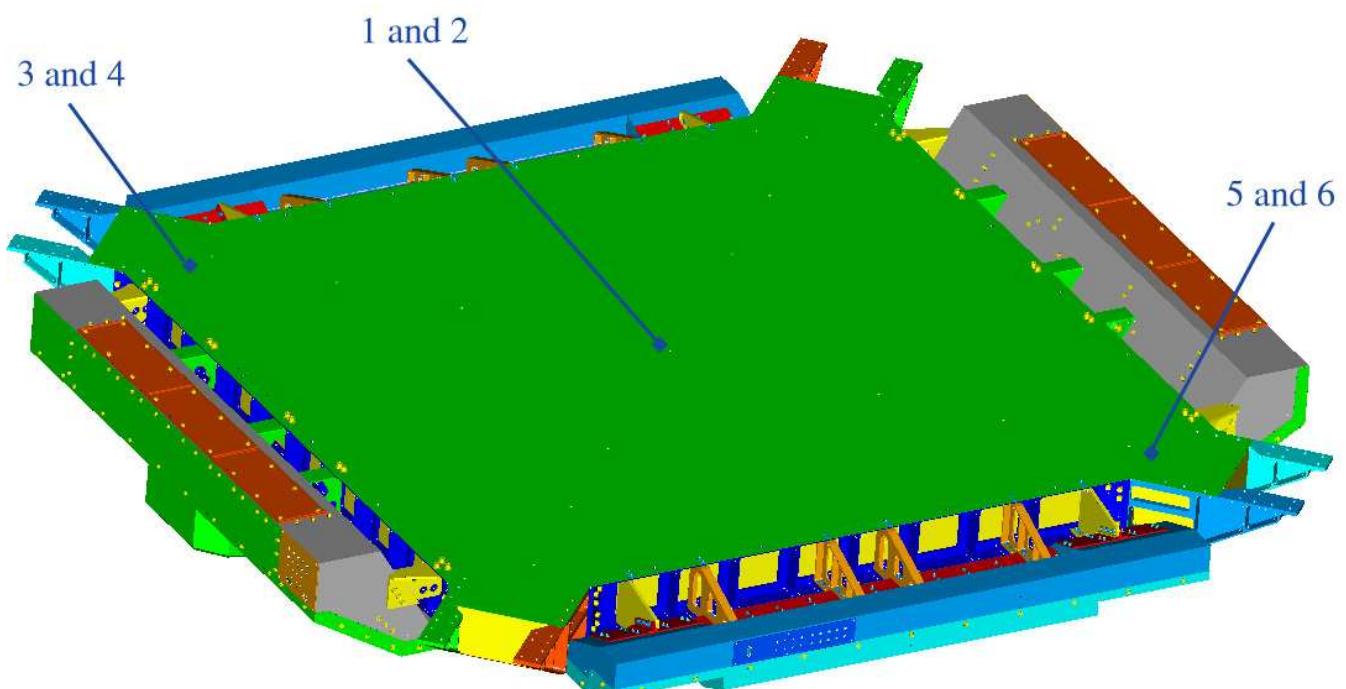


Figure 6-11 Thermal sensors location on honeycomb panel.

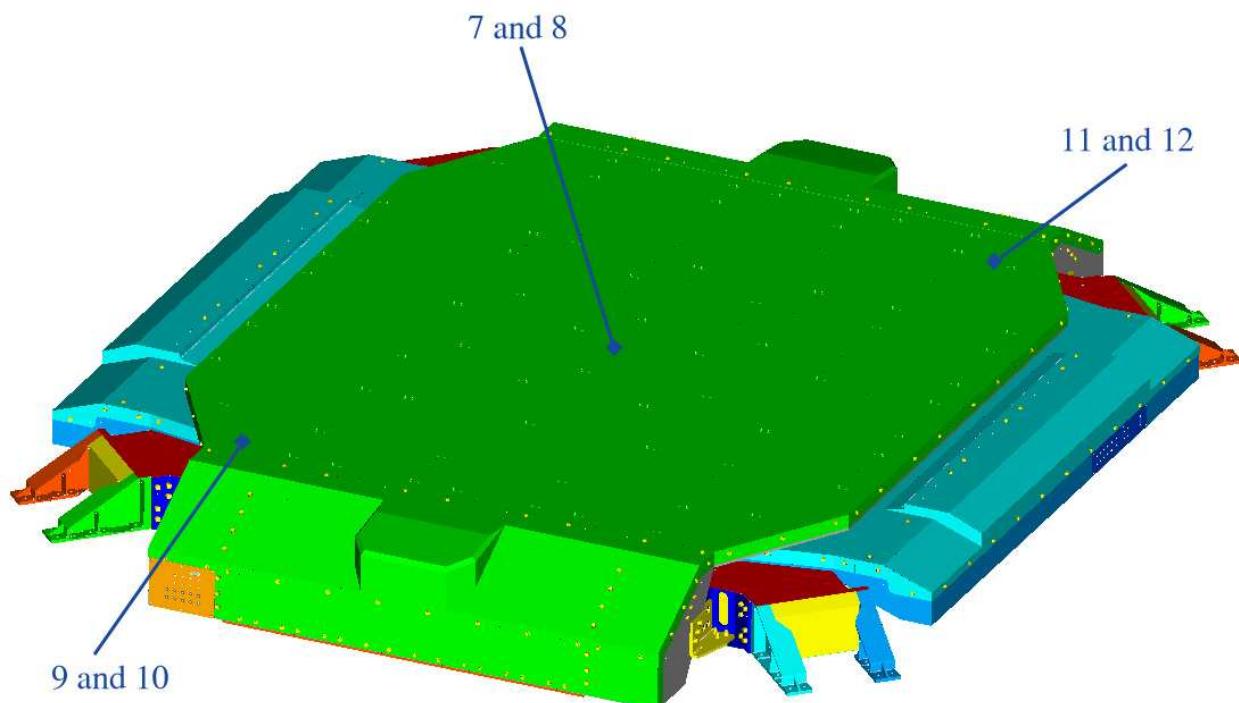


Figure 6-12 Thermal sensors location on carbon fiber panel

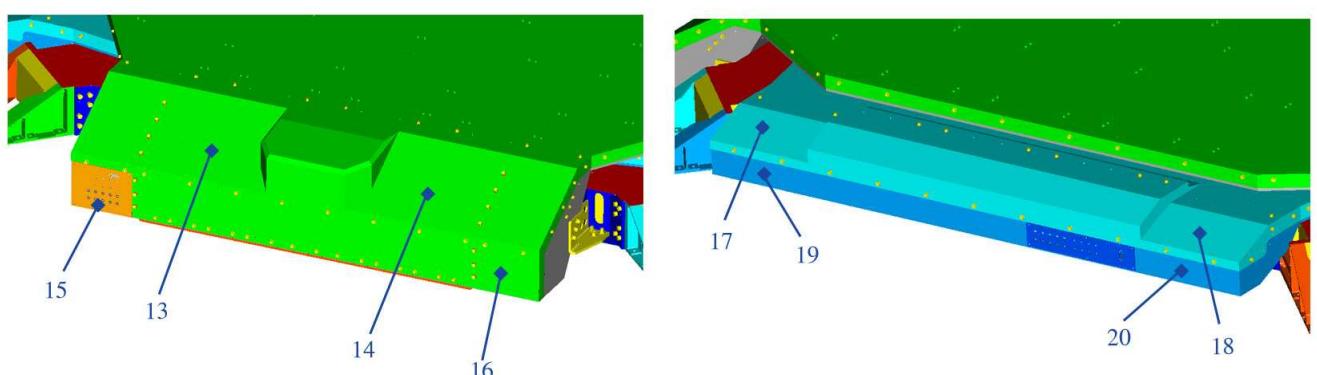


Figure 6-13 Thermal sensors location on lower lateral box +Y and +X

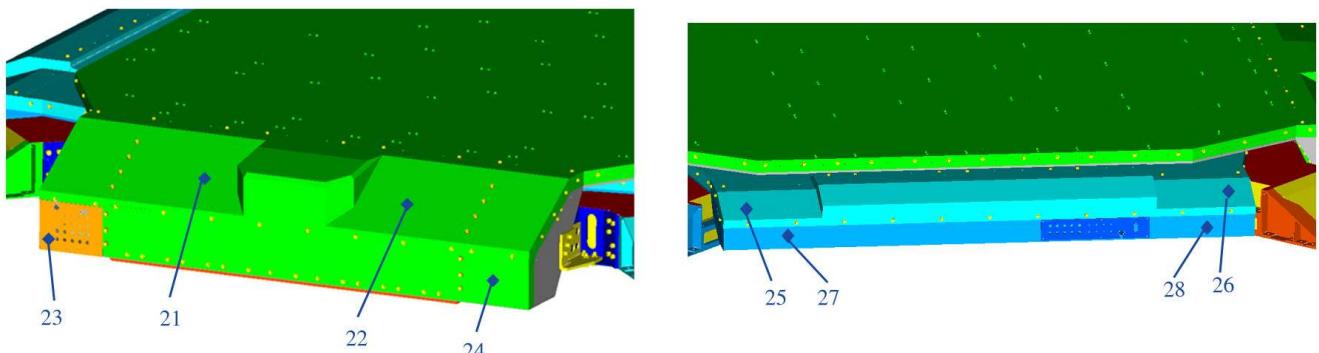


Figure 6-14 Thermal sensors location on lower lateral box -Y and -X

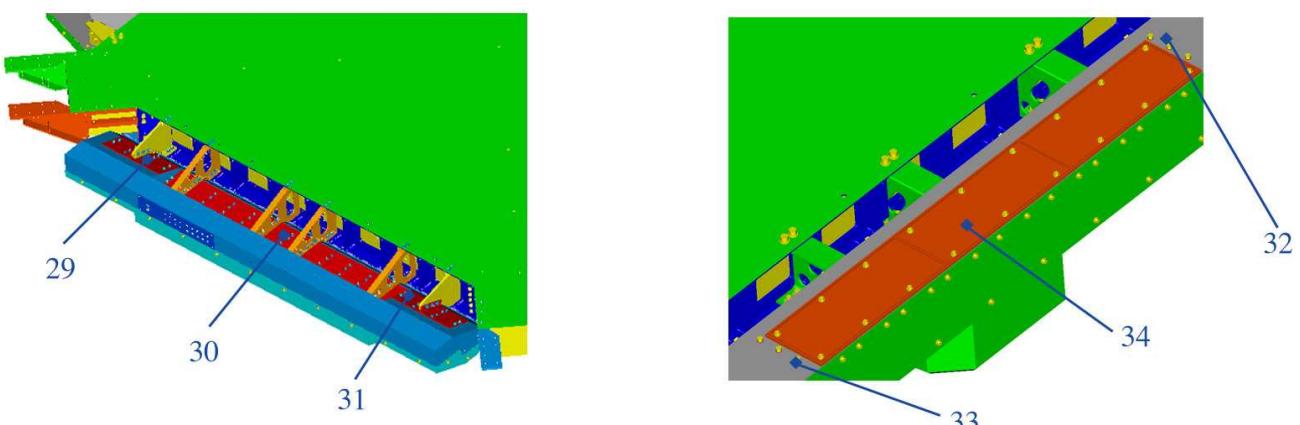


Figure 6-15 Thermal sensors location on upper lateral boxes +Y and +X

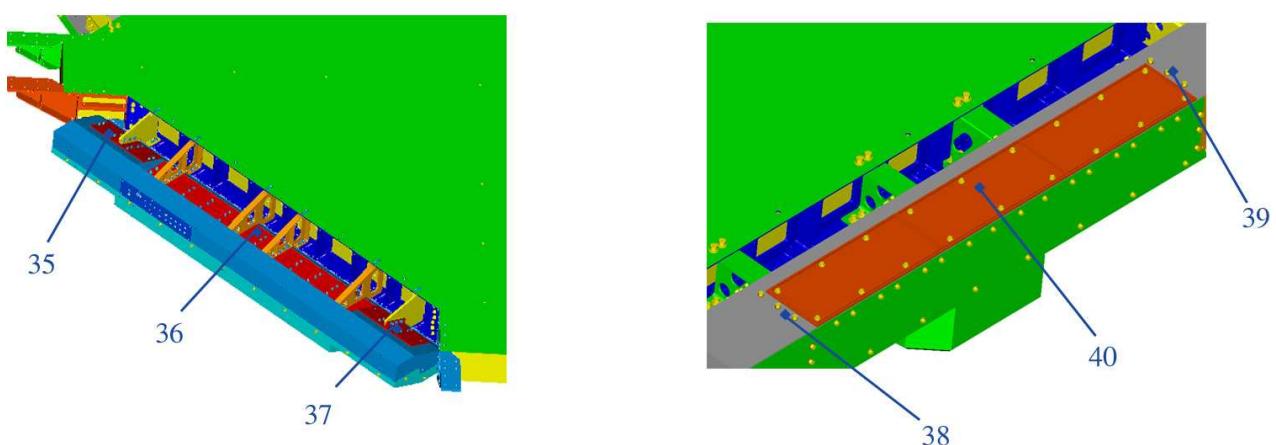


Figure 6-16 Thermal sensors location on upper lateral boxes -Y and -X

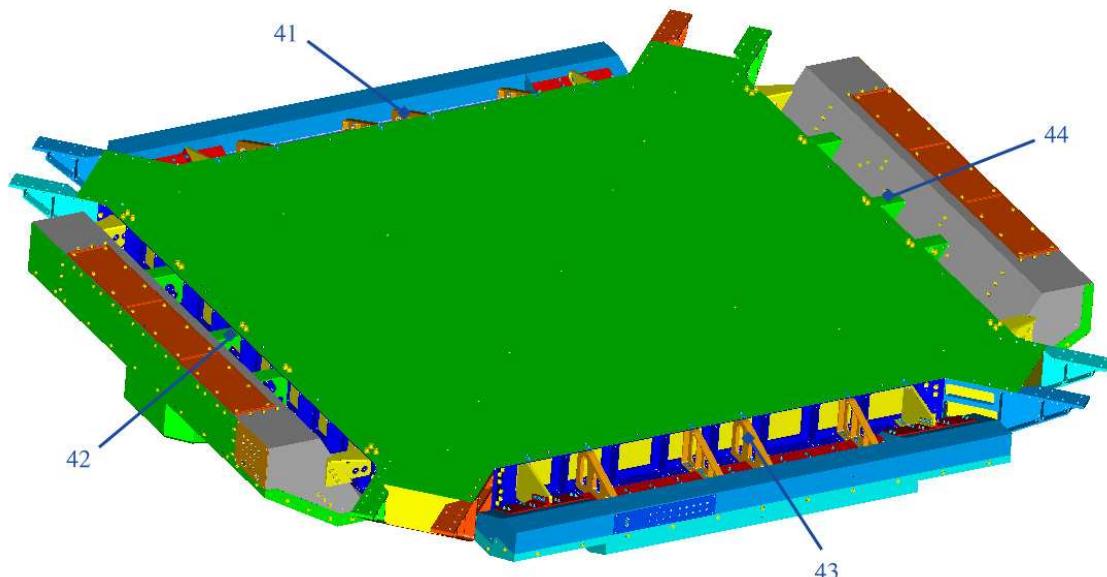


Figure 6-17 Thermal sensors location on support structure

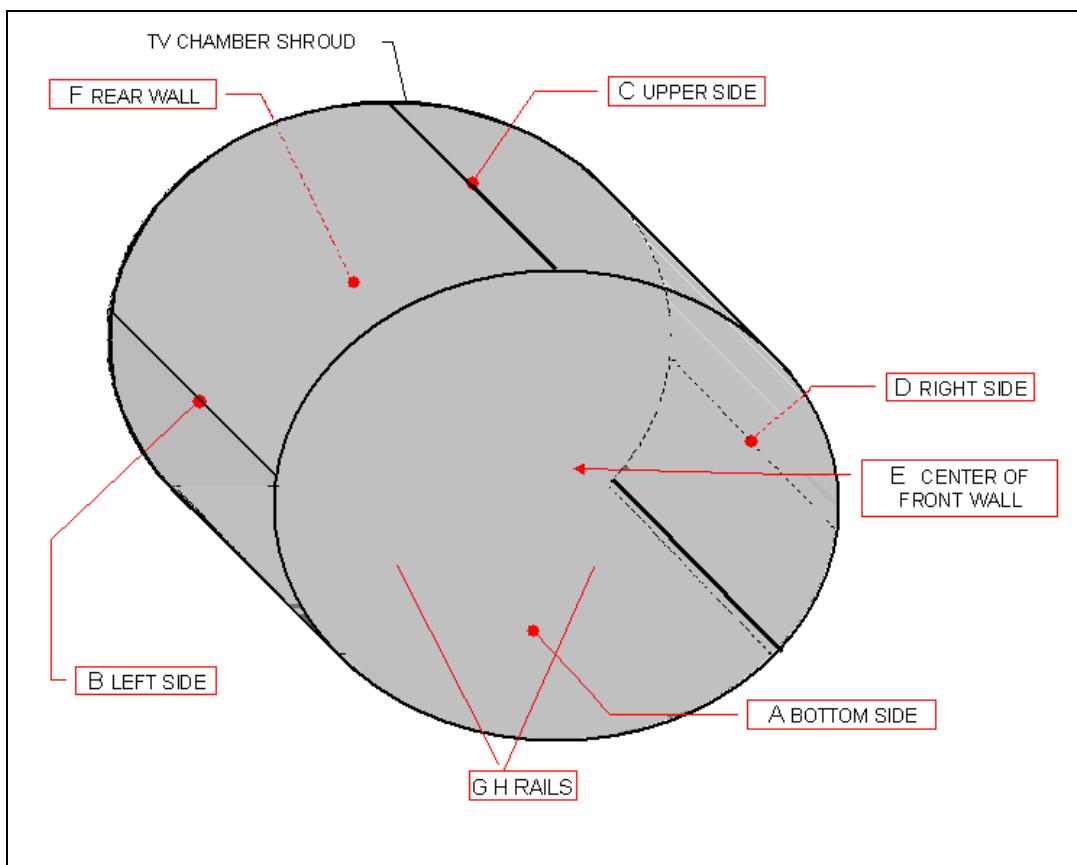


Figure 6-18 TV Chamber minimal thermal sensors layout

6.2.3 TEMPERATURE CONTROL POINTS

The Control Points (CP) for the test will be on the external box. The location is shown in the following pictures.

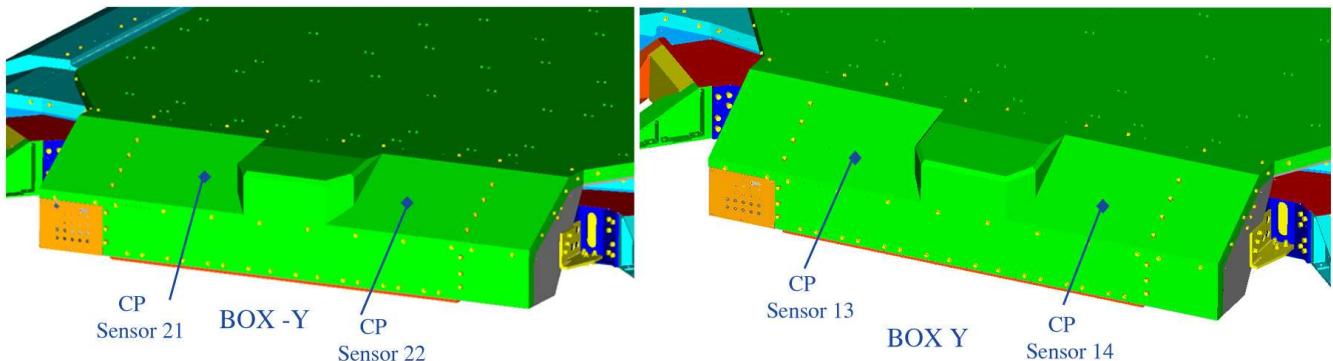


Figure 6-19 CP location on the lateral boxes (+/-Y)

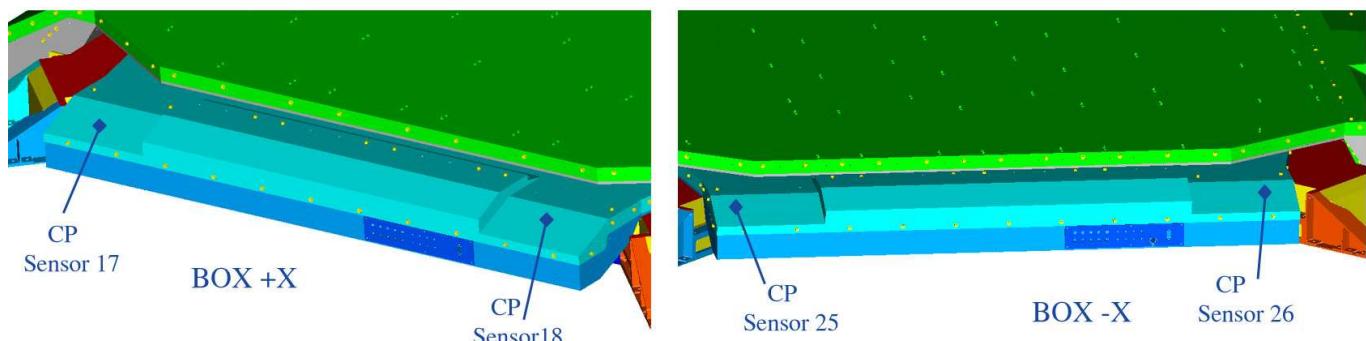


Figure 6-20 CP location on the lateral boxes (+/-X)

In the thermal model a node must be present in the location of the chosen CP.

6.3 FUNCTIONAL TESTS

Functional tests will be run by INFN according to requirements given in ANNEX A. These requirements are provided for reference only.

7. INSTRUMENTATION AND TEST EQUIPMENT

The complete list of the instrumentation used during the test shall be recorded in Table 7-1. The list shall be filled up during tests and reported in Test Report.

In addition, a crane is necessary to:

- Move the unit inside the test site to the test facility.
- Lift and position the unit inside the test chamber (2 translation degrees of freedom might be required).
- Remove the unit from the test chamber.

The crane should be compatible with the eventual unit support inside the chamber.

 AMS-02-TOF UTOF THERMAL TEST PROCEDURE	N° Doc: <i>Doc N°:</i> AMS-TOF-PRO-002 Ediz.: <i>Issue:</i> 1 Pagina <i>Page</i> 24 di 41
--	---

8. TEST CONDITION

- The UUT shall be tested in its defined configuration: it shall properly closed, all electrical loads shall be present and the UUT interface function(s) shall be simulated.
- Unless otherwise specified, all measurements are to be performed at the following ambient condition:

Temperature	+25°C +/- 3°C
Relative Humidity (RH)	30% < RH < 60%
Pressure	Ambient
Cleanliness	100000 class
- All tests, unless otherwise specified, shall be performed by a suitable laboratory in a proper area. General disposition shall be applied to maximize personnel safety from potential hazards.
- Connectors savers shall be used on PFM model as applicable to protect the UUT interface connectors.
- Skilled personnel shall be employed.
- All used instruments shall meet the necessary accuracy and shall not degrade the UUT performances.

8.1 MEASUREMENTS ACCURACY

Unless otherwise specified, all measurements are to be performed at the following accuracy:

- Tolerance on minimum operative and Non operative temperature -3/0 °C
- Tolerance on maximum operative and Non operative temperature 0/+3 °C
- Temperature will be measured with a absolute uncertainty of ±1.5 °C
- Pressure:
 - 0/+5% of tolerance on max specified value for pressure above 1.3×10^2 Pa (1 Torr)
 - ±25% of tolerance on max specified value for pressure 1.3×10^{-1} to 1.3×10^2 Pa
 - ±80% of tolerance on max specified value for pressure lower than 1.3×10^{-1} Pa (10-3 Torr)

9. TEST PROFILE

The maximum and minimum TRP temperatures (i.e. as measured on the copper shields) are summarized in the following table (see RD 4):

AMS02 TOF Detector	TRP temperature During Tests¹
MAXIMUM OPERATING	+43°C
MINIMUM OPERATING	-32°C
MAXIMUM NON OPERATING	+50°C
MINIMUM NON OPERATING	-35°C

Table 9-1 Temperatures for UTOF

The test is characterized by 4 thermal cycles. During the non-operating phases the Dallas sensors cannot be acquired, therefore the TRP temperature will be monitored via the corresponding PT100.

During the operating phases, in the first characterizing cycle, the chamber shroud will be adjusted in steps until the temperature sensors on the TRP report a temperature equal to the limits presented in Table 9-1.

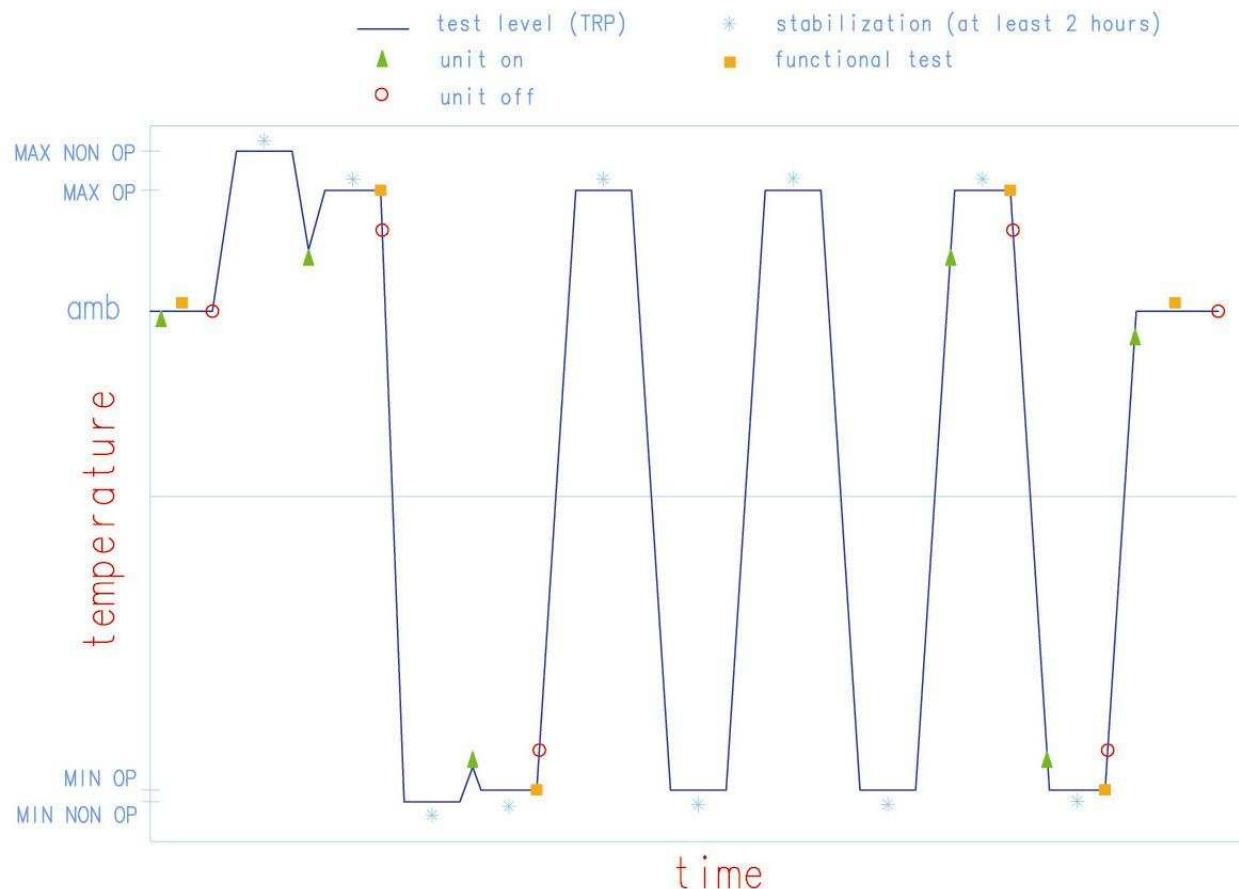


Figure 9-1 Thermal Vacuum Cycling (for the temperature level see Table 8-1) Stabilization criteria are provided in the step-by-step procedure.

¹ According with Annex B the temperature difference between the PMT Copper Shield and the PMT body is 2°C. The max/min operating temperature of the PMT body are +45°C/-30°C, consequently the max/min operating temperature of the TRP is 2°C lower, namely +43°C/-32°C. These considerations don't apply to the non-operating conditions, when the TRP and the PMT body are isothermal.

 AMS-02-TOF	N° Doc: Doc N°: AMS-TOF-PRO-002 Ediz.: 1 Data: 28/05/2007 Issue: Pagina Page 26 di 41
UTOF THERMAL TEST PROCEDURE	

10. TEST SUCCESS CRITERIA

Thermal cycling tests shall be considered successful if the following criteria will be satisfied:

- a. Definition of the Maximum/Minimum CP temperature with respect to the maximum/minimum PMT (TRP) allowed temperatures.
- b. Survival (minimum) temperature definition.
- c. Internal thermal design is performing according to the specification, i.e. the internal heat dissipating sources are well sunk to the UTOF body, hence showing small ΔT .

The following goal is under INFN responsibility:

- Absence of degradation or malfunction of UTOF during and after exposure to extreme hot and cold environments.

11. TEST PROCEDURE VARIATION SHEET

In case that for any reason the test procedure has to be changed, the change shall be described in a Procedure Variation Sheet (PVS) as shown in the next page.

The PVS shall contain:

- Reference to the test procedure to be changed
- Reference to the relevant test, procedure page and paragraph
- Description of the change, possibly in the form was....is.....
- Reason for change
- Test Engineer, QA, Test conductor signatures and dates
- Customer signature and date (when required).

Each PVS shall be identified by a reference number provided in sequential order.

All the generated PVS shall be collected in a dedicated section of the Test Report.



AMS-02-TOF

UTOF THERMAL TEST PROCEDURE

N° Doc: AMS-TOF-PRO-002
Doc N°:
Ediz.: 1 Data: 28/05/2007
Issue:
Pagina 27 di 41
Page

PROCEDURE VARIATION SHEET ref. N°:

Test Procedure Ref.:	Page Revised:	Paragraph Revised:
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Description of Change:

Reason for Change:

CONCURRENCE

Test Conductor	QA	System Eng.		Customer
Date	Date	Date		Date

 AMS-02-TOF	N° Doc: <i>Doc N°:</i> AMS-TOF-PRO-002
UTOF THERMAL TEST PROCEDURE	Ediz.: <i>Issue:</i> 1
	Data: <i>Date:</i> 28/05/2007

12. TEST DATA SHEETS

The step-by-step procedure sheets are provided in the following pages.

12.1 DATA SHEETS FILLING UP

The following fields of the data sheets:

- UUT DATA (including Model, Item, C.I., S/N)
- Measured value

shall be filled up during the test performances and shall be part of the Test Report together with photographs, sketches, etc. eventually useful to document the test execution/result.

Remarks field shall be used as a minimum to provide, where appropriate, reference to NCRs and PVS.

Test Report reference data shall be added in the relevant field.

Each data sheet (including the attachments) shall be certified by the **Test Conductor** signature and date.

AMS-02-TOF

UTOF THERMAL TEST PROCEDURE

N° Doc: **AMS-TOF-PRO-002**
 Doc N°:
 Ediz.: **1** Data: **28/05/2007**
 Issue:
 Pagina **29** di **41**
 Page

N° Doc:
 Doc N°:
 Ediz.:
 Issue:
 Pagina **di**
 Page **of**

TEST PROCEDURE REFERENCE

TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
Vacuum thermal cycles						
0. 0	PRELIMINARY OPERATIONS					
0. 1	Record the characteristics of the UUT (S/N, if any)					
0. 2	Take the UTOF out of the container		OK			
0. 3	Position the UTOF on the mounting panel inside the chamber		OK			
0. 4	Connect the electronic cables to the unit and verify harness.		OK			
0. 5	Place the thermal sensors on the TV Chamber according to of Figure 6-18, Figure 6-11, Figure 6-12, Figure 6-13, Figure 6-14, Figure 6-15, Figure 6-16, Figure 6-17 and Table 6-1 :		OK			
0. 6	Connect the Test Equipment to the cables outside the chamber		OK			
0. 7	Test the flight and test thermal sensors in order to verify the signal		OK			
0. 8	Switch UUT ON at ambient temperature		ON			
0. 9	Perform <u>functional test</u> (see Annex A)		OK			
0. 10	Switch UUT OFF Record the ambient temperature and the TRP (with the flight sensor)		OFF			
0. 11	Close the thermal vacuum chamber.		CLOSED			
0. 12	Start data acquisition		START SCAN			

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> <p style="text-align: center;">UTOF THERMAL TEST PROCEDURE</p>	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 30 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
1. 0	First thermal cycle					
1. 1	Switch ON the vacuum pump			ON		
1. 2	When chamber pressure is lower than 1×10^{-4} hPa, increase the TV chamber temperature in order to reach the maximum non-operating temperature on TRP.			$P < 1 \times 10^{-4}$ hPa		
1. 3	When $\Delta T / \Delta t \leq 3K/h$ is reached over at least 10 minutes observation time, temperature shall stabilize for at least 2 hours. Record elapsed time and temperature. Record Chamber temperature.			$t > 2$ hr $T_{TRP} = +50^\circ C$ $T_{chamber} =$		
1. 4	Decrease the TV chamber temperature in order to reach $+40^\circ C$ on the TRP			OK $T_{TRP} = +40^\circ C$		
1. 5	Switch ON the TOF and record the power consumption/dissipation			$T_{TRP} = +40^\circ C$ ON $P_{PMT} = 0.04W$		
1. 6	Increase gradually the CP temperature until the hottest TRP reports a temperature equal to $+43^\circ C$ (maximum operating temperature)			$T_{TRP} = +43^\circ C$		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> <p style="text-align: center;">UTOF THERMAL TEST PROCEDURE</p>	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 31 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
1. 7	<p>When $\Delta T/\Delta t \leq 3K/h$ is reached over at least 10 minutes observation time(on the hottest TRP temperature sensor) :</p> <p>Stabilize for at least 2 hours.</p> <p>Record elapsed time and temperature.</p> <p>Record the TRP, CP and TV Chamber shroud temperature.</p> <p>Record the power consumption/dissipation</p>			$t > 2 \text{ hr}$ $T_{\text{TRP}} = +43^\circ\text{C}$ $P_{\text{PMT}} = 0.04\text{W}$	$T_{\text{CP-MAXOP}} =$ $T_{\text{chamber-MAXOP}} =$	
1. 8	Perform <u>functional test</u> (see Annex A)		OK			
1. 9	Switch OFF the UTOF		OFF			
1. 10	Decrease the TV chamber temperature in order to reach the minimum non-operating temperature on TRP.		$T_{\text{TRP}} = -35^\circ\text{C}$			
1. 11	<p>When $\Delta T/\Delta t \leq 3K/h$ is reached over at least 10 minutes observation time(on the coldest TRP temperature sensor) :</p> <p>Stabilize for at least 2 hours.</p> <p>Record elapsed time and temperature.</p> <p>Record the TRP, CP and TV Chamber shroud temperature.</p>		$t > 2 \text{ hr}$ $T_{\text{TRP}} = -35^\circ\text{C}$	$T_{\text{chamber}} =$		
1. 12	Increase the CP temperature until the coldest TRP reports a temperature equal to -30°C (minimum switch ON)		OK $T_{\text{TRP}} = -30^\circ\text{C}$			
1. 13	Switch ON the UTOF and record the power consumption/dissipation		$T_{\text{TRP}} = -30^\circ\text{C}$ ON $P_{\text{PMT}} = 0.04\text{W}$			

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Bologna INFN Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> <p style="text-align: center;">UTOF THERMAL TEST PROCEDURE</p>	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 32 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
1. 14	Decrease gradually the CP temperature until the coldest TRP reports a temperature equal to -32°C (minimum operating tempe rature).			$T_{TRP}=-32^{\circ}\text{C}$		
1. 15	When $\Delta T/\Delta t \leq 3\text{K/h}$ is reached over at least 10 minutes observation time(on the coldest TRP temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.			$t > 2 \text{ hr}$ $T_{TRP}=-32^{\circ}\text{C}$ $P_{PMT}=0.04\text{W}$	$T_{CP-MINOP}=$ $T_{chamber-MINOP}=$	
1. 16	Perform <u>functional test</u> (see Annex A)			OK		
1. 17	Switch OFF the UTOF			OFF		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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AMS-02-TOF

UTOF THERMAL TEST PROCEDURE

N° Doc: **AMS-TOF-PRO-002**

Doc N°:
Ediz.: **1** Data: **28/05/2007**
Issue:

Pagina **33** di **41**
Page

N° Doc:
Doc N°:

Ediz.:
Issue:
Data:
Date:

Pagina **di**
Page

TEST PROCEDURE REFERENCE

TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
2. 0	Second thermal cycle					
2. 1	Increase the TV chamber temperature in order to reach the maximum operating temperature (see TCP-MAXOP and Tchamber-MAXOP)		OK			
2. 2	Increase gradually the CP temperature until the hottest TRP reports a temperature equal to +43°C (maximum operating tempe rature)		$T_{TRP}=+43^{\circ}\text{C}$			
2. 3	When $\Delta T/\Delta t \leq 3\text{K/h}$ is reached over at least 10 minutes observation time(on the hottest TRP temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.		$t > 2 \text{ hr}$ $T_{TRP}=+43^{\circ}\text{C}$	$T_{CP-\text{MAXOP}}=$ $T_{\text{chamber-MAXOP}}=$		
2. 4	Decrease the TV chamber temperature in order to reach the minimum operating temperature (see TCP-MINOP and Tchamber-MINOP)		OK			
2. 5	Decrease gradually the CP temperature until the coldest TRP reports a temperature equal to -32°C (minimum operating tempe rature).		$T_{TRP}=-32^{\circ}\text{C}$			
2. 6	When $\Delta T/\Delta t \leq 3\text{K/h}$ is reached over at least 10 minutes observation time(on the coldest TRP temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.		$t > 2 \text{ hr}$ $T_{TRP}=-32^{\circ}\text{C}$	$T_{CP-\text{MINOP}}=$ $T_{\text{chamber-MINOP}}=$		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Bologna INFN Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> UTOF THERMAL TEST PROCEDURE	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 34 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
3.0	Third thermal cycle					
3. 1	Increase the TV chamber temperature in order to reach the maximum operating temperature (see TCP-MAXOP and Tchamber-MAXOP)			OK		
3. 2	Increase gradually the CP temperature until the hottest TRP reports a temperature equal to +43°C (maximum operating tempe rature)			$T_{TRP}=+43^{\circ}C$		
3. 3	When $\Delta T/\Delta t \leq 3K/h$ is reached over at least 10 minutes observation time(on the hottest TRP temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.			$t > 2\ hr$ $T_{TRP}=+43^{\circ}C$	$T_{CP-MAXOP}=$ $T_{chamber-MAXOP}=$	
3. 4	Decrease the TV chamber temperature in order to reach the minimum operating temperature (see TCP-MINOP and Tchamber-MINOP)			OK		
3. 5	Decrease gradually the CP temperature until the coldest TRP reports a temperature equal to -32°C (minimum operating tempe rature).			$T_{TRP}=-32^{\circ}C$		
3. 6	When $\Delta T/\Delta t \leq 3K/h$ is reached over at least 10 minutes observation time(on the coldest TRP temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.			$t > 2\ hr$ $T_{TRP}=-32^{\circ}C$	$T_{CP-MINOP}=$ $T_{chamber-MINOP}=$	

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> <p style="text-align: center;">UTOF THERMAL TEST PROCEDURE</p>	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 35 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
4. 0	Fourth thermal cycle					
4. 1	Increase the TV chamber temperature in order to reach the maximum operating temperature (see TCP-MAXOP and Tchamber-MAXOP)			OK		
4. 2	Switch ON the TOF and record the power consumption/dissipation			$T_{TRP}= +40^\circ C$ ON $P_{PMT}=0.04W$		
4. 3	Increase gradually the CP temperature until the hottest TRP reports a temperature equal to $+43^\circ C$ (maximum operating tempe rature)			$T_{TRP}=+43^\circ C$		
4. 4	When $\Delta T/\Delta t \leq 3K/h$ is reached (on all the temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.			$t > 2 \text{ hr}$ $T_{TRP}=+43^\circ C$ $P_{PMT}=0.04W$	$T_{CP-MAXOP}=$ $T_{chamber-MAXOP}=$	
4. 5	Perform <u>functional test</u> (see Annex A)			OK		
4. 6	Switch OFF the UTOF			OFF		
4. 7	Decrease the TV chamber temperature in order to reach the minimum operating temperature (see TCP-MINOP and Tchamber-MINOP)			OK		
4. 8	Switch ON the UTOF and record the power consumption/dissipation			$T_{TRP}=-30^\circ C$ ON $P_{PMT}=0.04W$		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
4. 9	Decrease gradually the CP temperature until the coldest TRP reports a temperature equal to -32°C (minimum operating tempe rature).			$T_{TRP}=-32^{\circ}\text{C}$		
4. 10	When $\Delta T/\Delta t \leq 3\text{K/h}$ is reached (on all the temperature sensor) : Stabilize for at least 2 hours. Record elapsed time and temperature. Record the TRP, CP and TV Chamber shroud temperature.			$t > 2 \text{ hr}$ $T_{TRP}=-32^{\circ}\text{C}$ $P_{PMT}=0.04\text{W}$	$T_{CP-MINOP}=$ $T_{chamber-MINOP}=$	
4. 11	Perform <u>functional test</u> (see Annex A)			OK		
4. 12	Switch OFF the UTOF			OFF		
4. 13	Increase the temperature in order to reach ambient temperature .			OK		
4. 14	When the UUT is at the ambient temperature ($+/-5^{\circ}\text{C}$) . Switch ON the UTOF and perform the Functional test according to Annex A. Switch OFF the UTOF Increase the pressure in order to reach the ambient pressure.					
4. 15	Stop data acquisition			STOP SCAN		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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 Bologna INFN Istituto Nazionale di Fisica Nucleare	<h1 style="text-align: center;">AMS-02-TOF</h1> <p style="text-align: center;">UTOF THERMAL TEST PROCEDURE</p>	N° Doc: AMS-TOF-PRO-002 Doc N°: Ediz.: 1 Data: 28/05/2007 Issue: Pagina 37 di 41 Page	N° Doc: Doc N°: Ediz.: Issue: Pagina Page
		TEST PROCEDURE REFERENCE	TEST REPORT REFERENCE

UUT DATA :		Model	Item	C.I.	S/N	
STEP n°	TEST SEQUENCE			EXPECTED VALUE	MEASURED VALUE	REMARKS
4. 16	Open the chamber			OK		
4. 17	Remove test temperature sensors from the UUT			OK		
4. 18	Disconnect the electronic cables			OK		
4. 19	Remove the unit from the TV chamber			OK		

DATE:	TEST CONDUCTOR	QA	CUSTOMER
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13. ANNEX A: FUNCTIONAL TEST (FOR INFN USE ONLY)

Functional tests will be run according to UTOF group requirements.

Purpose of the functional test is to have a fast outlook of the behaviour of scintillation counters, PMT and on-detector electronics. All PMT of the UTOF will be set at a HV between 1950 Volt and 2150 Volt. All the 4 front-end SFEC cards will be powered and connected to a DAQ system to readout the individual PMT dynode signal. The anode signals are readout by two SFEC cards for anodes, external to the UTOF. The anode signals of one central counter of plane X and one of plane Y will be monitored and processed by a 4 channels digital scope to generate a trigger signal at the passage of cosmic rays and the SFEC DAQ system will register the dynode signals and the anode signals of the interested counters. The expected rate of cosmic rays being 2 Hz a 1-2 hours run should be sufficient to test the mean value and the rms for all PMT. In this way the mean pulse heights should be controlled with a few thousand events per counter at the 5 % level.

Cable connections of the TOF to the Thermo-Vacuum Chamber Flange has been already defined with the operating staff in Terni. It is shown schematically in Figure 13-1.

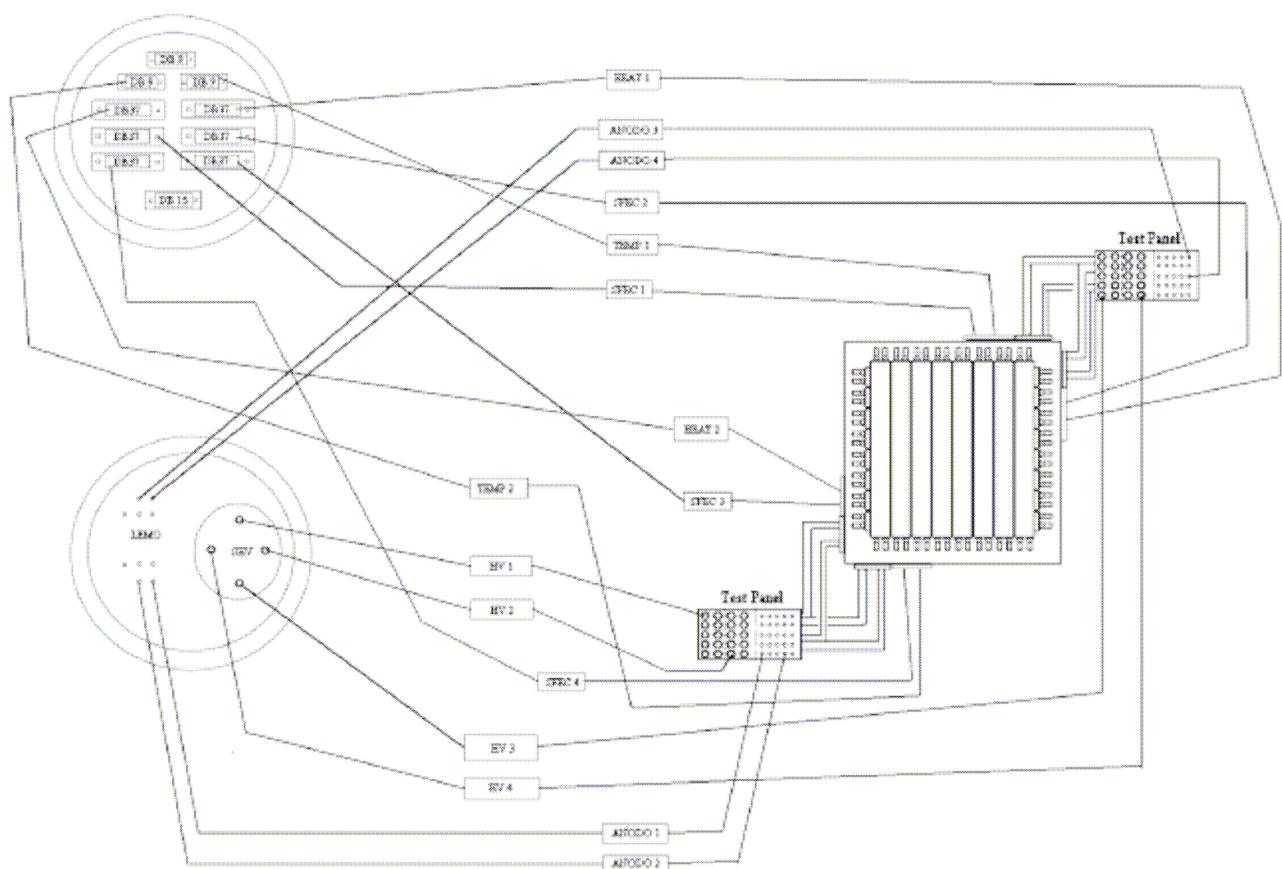


Figure 13-1 TV Chamber Flange Cabling

The set-up for the Functional Test (FT) consists in :

1. Commercial PMT High Voltage power supply with four channels capable of 1mA at 2000 V, with current limiter and short circuit protection
2. Commercial low voltage power supply + 3.3 V 150 W
3. Commercial 4 channels Digital Scope with logic functions built in
4. Custom DAQ card with PC interface
5. Dallas sensors custom reading card with a PC interface
6. Commercial Portable PC for data storage and analysis

A sketch of the Functional Test Setup is shown in Figure 13-2.

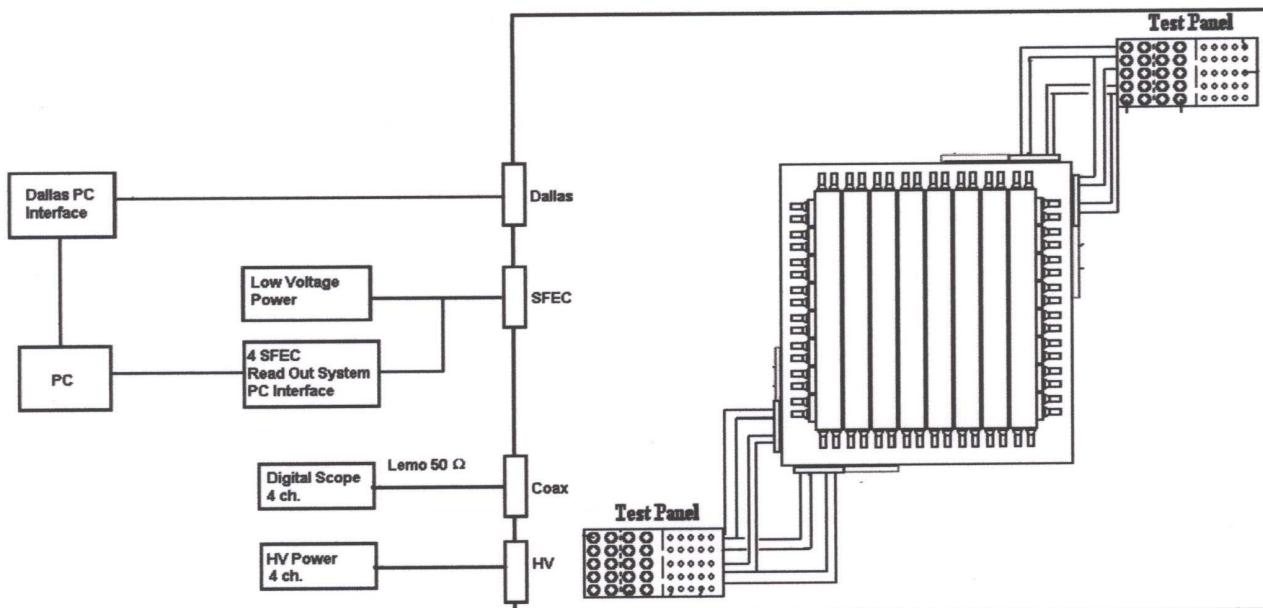


Figure 13-2 Functional Test Setup

Functional Test Procedure

Let $T = 0$ be the starting time of the FT, the following is a time schedule of the functional test.

1. $T = 0$ Power up of the PMT and of the front-end electronics OK
2. 1 m Control of the HV Supply power dissipation OK
3. 5 m Visual inspection of Scope anode signals and trigger OK
4. 15 m Dynode spectra scan for anomalies OK
5. 30 m Dallas sensor readout and start of data acquisition run OK
6. 2 h End of data acquisition run and start of off-line analysis

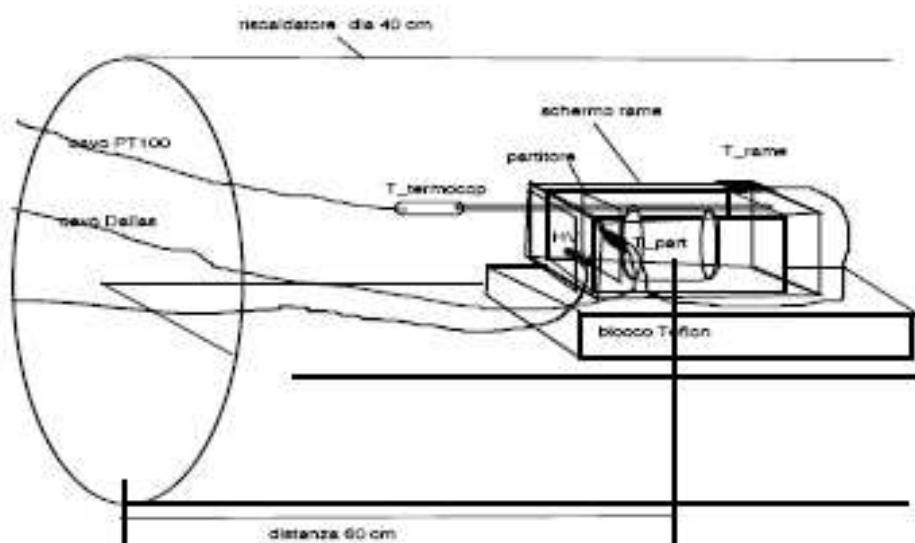
The numbered run data file will be copied in data storage and will undergo a preliminary off-line analysis in about two hours.

The length of the data-taking run can be variable according to the thermo-vacuum conditions and the thermal cycles program. Each OK means that suitable actions (not described here) will be taken in case of failures.

14. ANNEX B: PMT +COPPER SHIELD TV-TEST

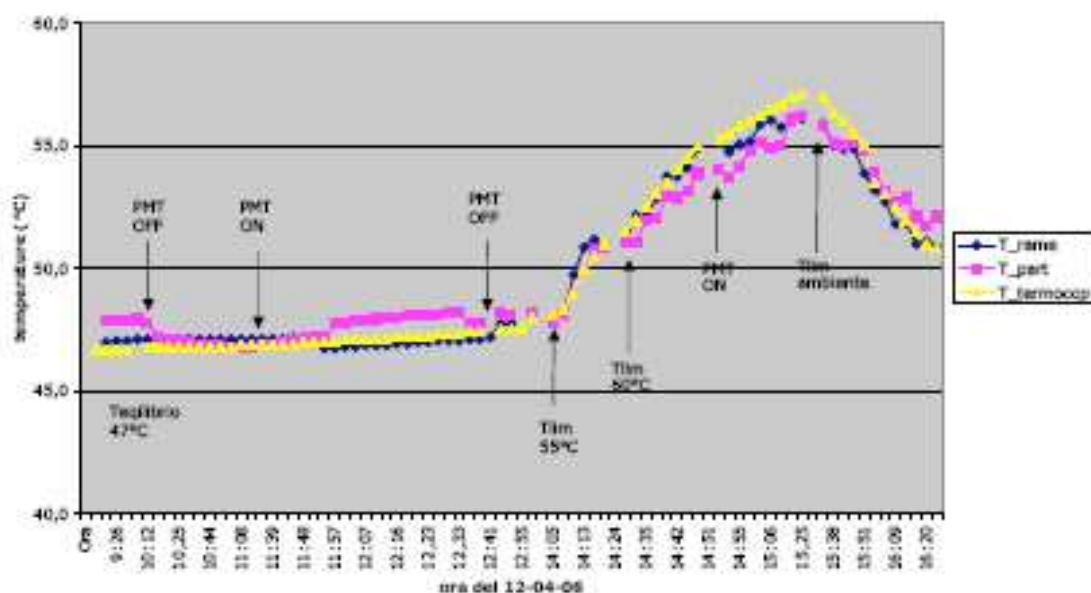
From Prof. Palmonari received 12/04/06

Set-up test TVT di un PMT con schermo di rame



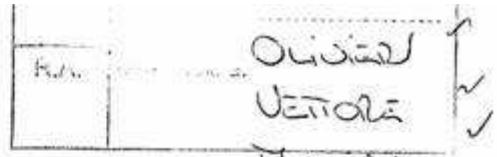
Questo è il run di oggi. Siamo partiti da una situazione stabile tutta la notte.

Termica PMT + schermo rame



15. ANNEX C: TEMPERATURE LEVEL DEFINITION

Spett. Carlo Gavazzi Space, S.p.A.
 Via Gallarate 150
 20151 MILANO
 FAX: 02 3086458



Att.ne: Sig. Massimiliano Olivier

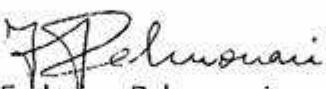
Facendo seguito alla teleconferenza tenutasi in data odierna con Carlo Gavazzi Space e il Thermal Working Group della AMS-02 Collaboration, vi confermiamo che per ridurre l'aging dei PMT del detector TOF, effetto direttamente proporzionale alla temperatura degli PMT stessi, è necessario contenere il valore della temperatura massima operativa e non operativa del test.

Nella seguente tabella sono pertanto definiti i valori di temperatura che dovranno essere utilizzati durante il Test di termovuoto del TOF:

AMS-02 TOF Detector	PMT temperature during test
MAXIMUM OPERATING	+ 45 °C
MINIMUM OPERATING	- 30 °C
MAXIMUM NON OPERATING	+ 50 °C
MINIMUM NON OPERATING	- 35 °C

Preghiamo pertanto CGS di inserire tali valori all'interno della nuova issue della procedura di test.

Con i migliori saluti


 Federico Palmonari
 Responsabile INFN del TOF Detector, Bologna

Bologna, 5 Aprile 2006